US009464609B2

(12) United States Patent
Jensen et al.

(10) Patent No.: US 9,464,609 B2
(45) Date of Patent: Oct. 11, 2016

(54) FUEL DELIVERY SYSTEM INCLUDING INTEGRATED CHECK VALVE

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 25 days.

(21) Appl. No.: **14/020,576**

(22) Filed: **Sep. 6, 2013**

(65) **Prior Publication Data**

US 2015/0068491 A1 Mar. 12, 2015

(51) **Int. Cl.**

F02M 69/04	(2006.01)
F02M 1/00	(2006.01)
F02M 37/00	(2006.01)
F16K 47/08	(2006.01)
F16K 15/04	(2006.01)

(52) **U.S. Cl.**

CPC ***F02M 37/0041*** (2013.01); ***F02M 37/0023*** (2013.01); ***F16K 15/044*** (2013.01); ***F16K 47/08*** (2013.01); *Y10T 137/0396* (2015.04); *Y10T 137/85978* (2015.04)

(58) **Field of Classification Search**

CPC F02M 37/20; F02M 37/025; F02M 37/0029; F02M 37/0023; F02M 5/12; F02M 21/0239; F02M 37/0017; B60K 15/077; F16L 37/34; F16K 15/033; H02K 5/12

USPC 123/445, 459, 495, 516, 506

See application file for complete search history.

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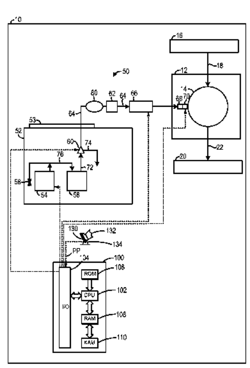
(57) ABSTRACT

A fuel delivery system is provided to reduce the pressure pulsations and noise vibration and harshness of direct injection systems. The fuel delivery system includes an elastic fuel line positioned between a first fuel pump and a second fuel pump and a check valve positioned in the elastic fuel line near the inlet of the high pressure pump, the check valve including an external housing having a peripheral surface with a greater diameter than an unstretched inner diameter of the elastic fuel line.

17 Claims, 5 Drawing Sheets



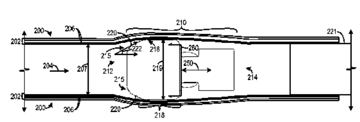


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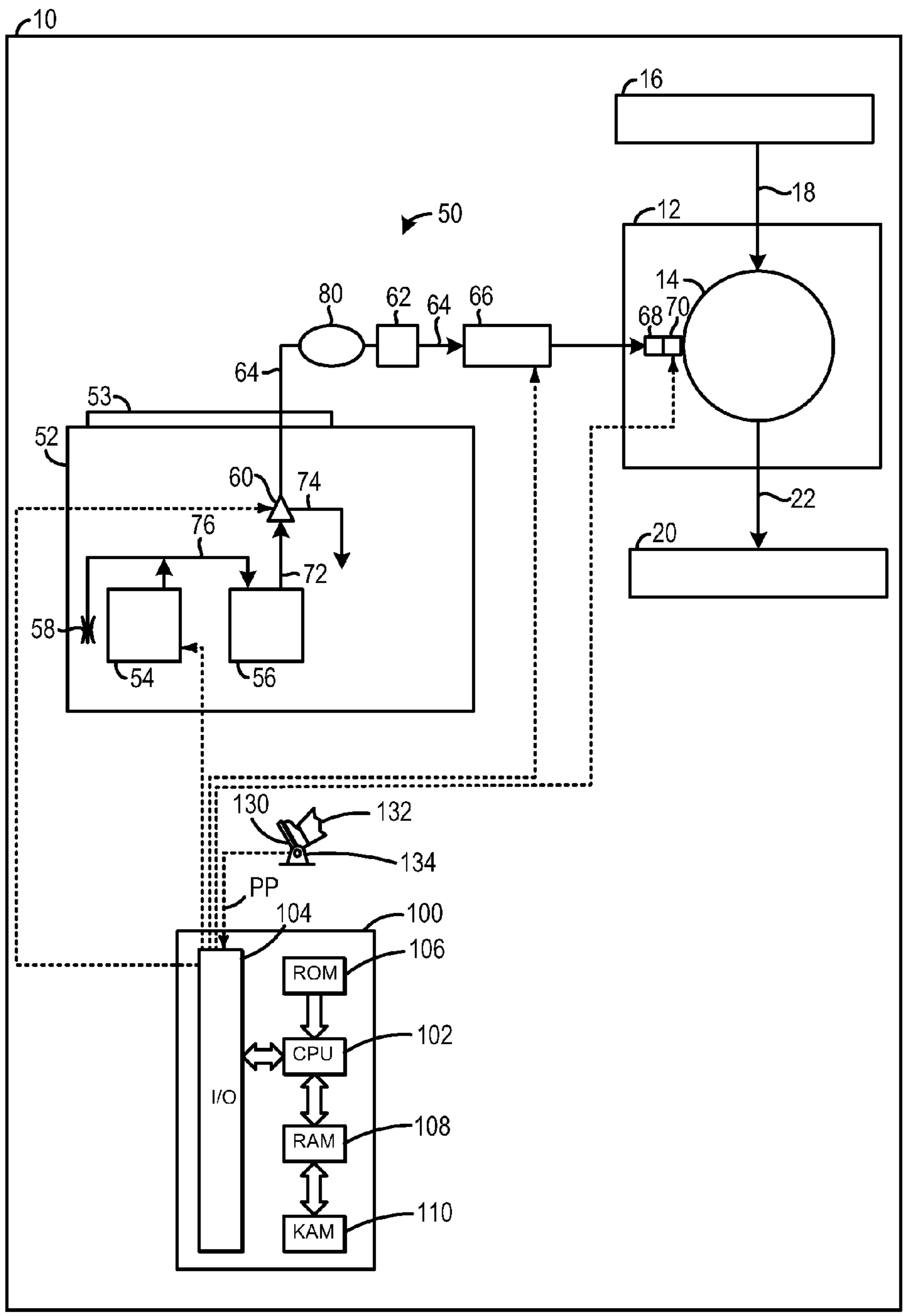
FIG. 1


10
16
18
50
12
14
80
62
64
66
68
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64
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52
60
74
76
72
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RAM
108
KAM
110

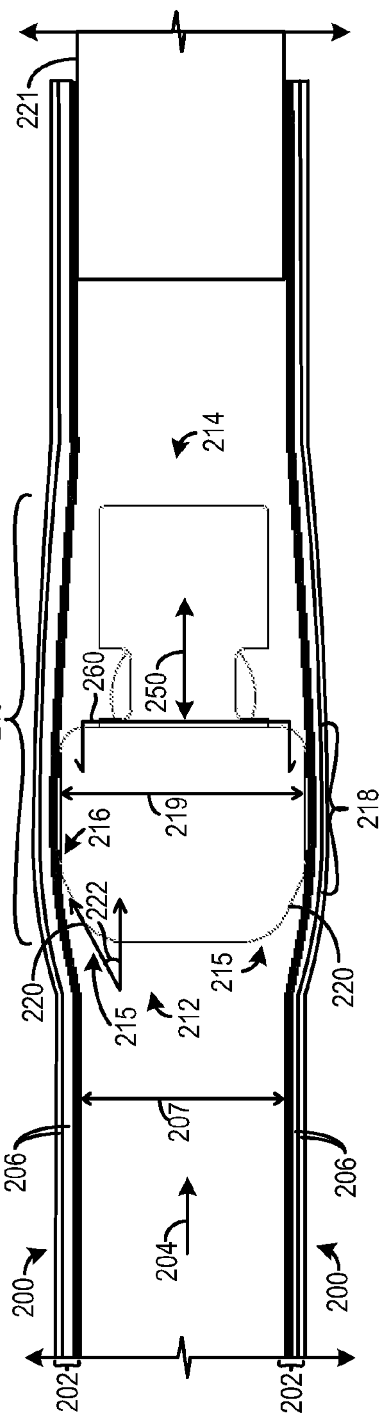

221
214
210
260
250
219
218
216
222
220
215
212
215
220
207
206
206
204
200
200
202
202

FIG. 2

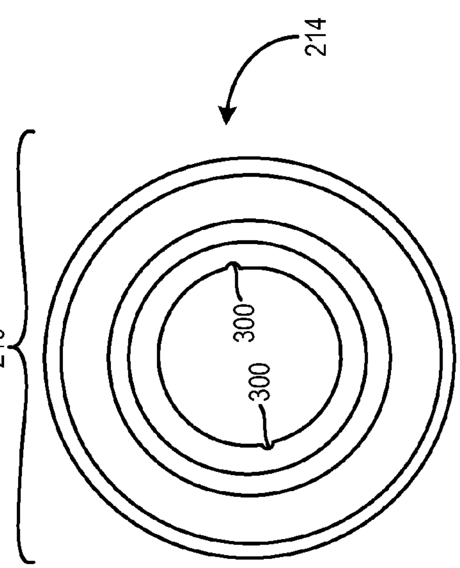

214
210
300
300

FIG. 3

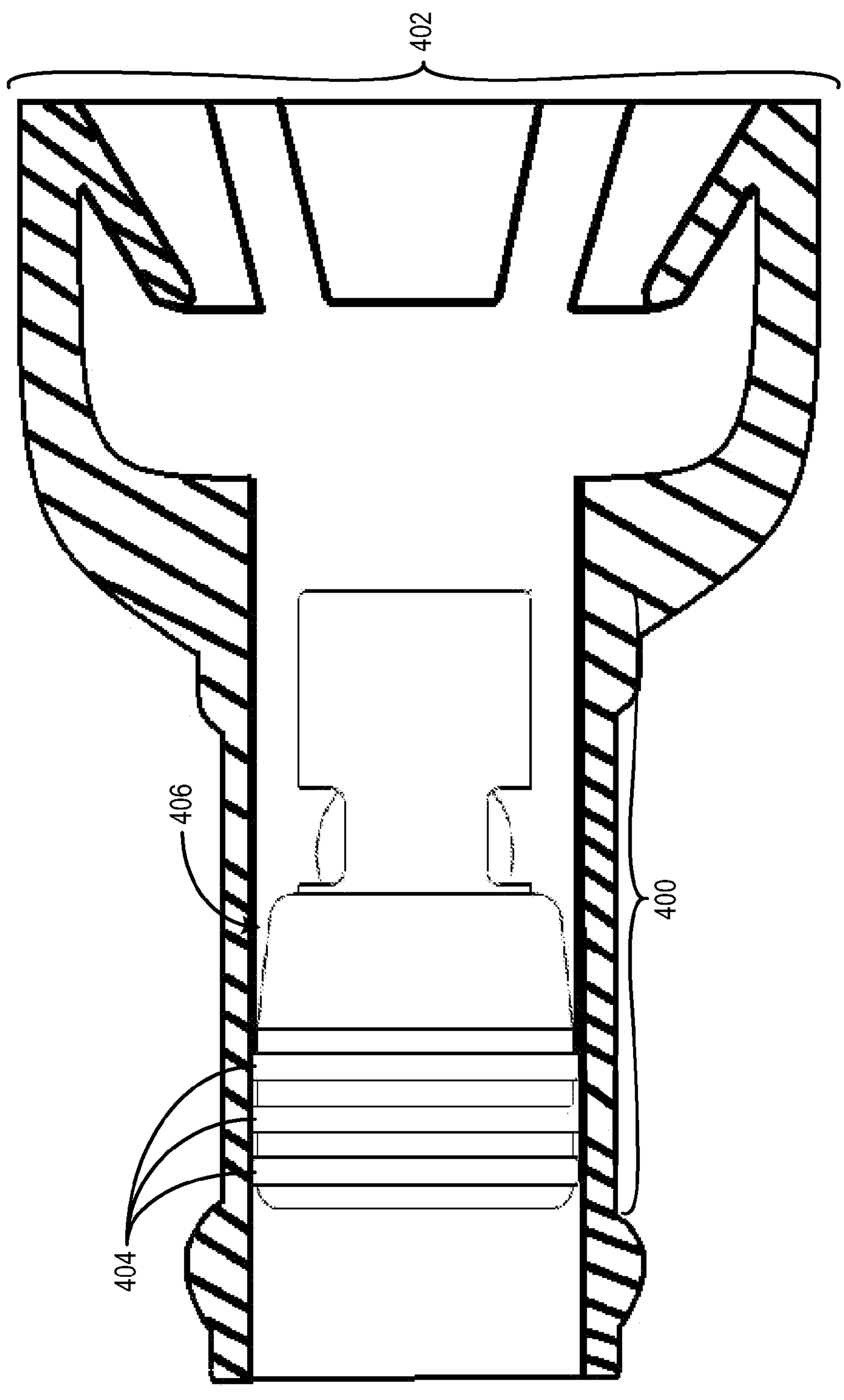


FIG. 4

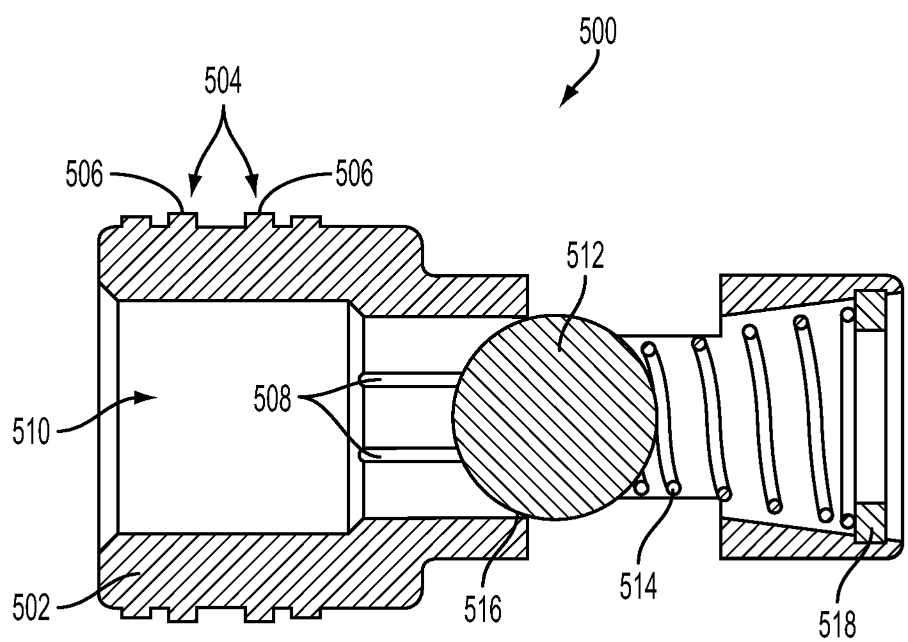
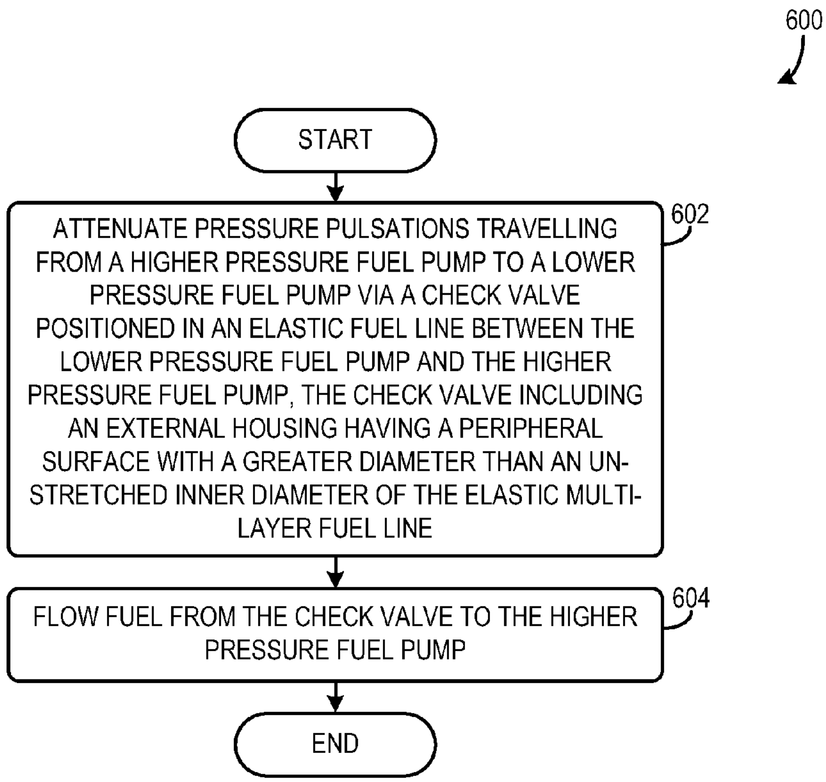


FIG. 5

FIG. 6


600
START
ATTENUATE PRESSURE PULSATIONS TRAVELLING FROM A HIGHER PRESSURE FUEL PUMP TO A LOWER PRESSURE FUEL PUMP VIA A CHECK VALVE POSITIONED IN AN ELASTIC FUEL LINE BETWEEN THE LOWER PRESSURE FUEL PUMP AND THE HIGHER PRESSURE FUEL PUMP, THE CHECK VALVE INCLUDING AN EXTERNAL HOUSING HAVING A PERIPHERAL SURFACE WITH A GREATER DIAMETER THAN AN UN-STRETCHED INNER DIAMETER OF THE ELASTIC MULTI-LAYER FUEL LINE
602
FLOW FUEL FROM THE CHECK VALVE TO THE HIGHER PRESSURE FUEL PUMP
604
END

FUEL DELIVERY SYSTEM INCLUDING INTEGRATED CHECK VALVE

FIELD

The present disclosure relates to a fuel delivery system in an engine.

BACKGROUND AND SUMMARY

Fuel delivery systems are used in vehicles to provide fuel to cylinders in the engine. Some fuel delivery systems may include multiple fuel pumps, such as a high pressure fuel pump and a low pressure fuel pump, to providing high pressure fuel to the cylinders. Increasing the pressure of the fuel delivery system may enable combustion efficiency to be increased, thereby reducing fuel consumption and/or increasing power output. However, fuel delivery systems may experience pressure pulsations in a variety of locations in the system. For instance, pressure pulses may be experienced between the fuel pumps and between the fuel rail and the high pressure fuel pump. As a result, the longevity of the pumps, fuel rail, etc., may be decreased due to the degradation of components caused by the pressure pulsations in the system. These pressure pulsations may also negatively affect the metering of the fuel provided to the combustion chamber, thereby reducing combustion efficiency. Moreover, the noise, vibration, and harshness (NVH) caused by the pulsations also decreases customer satisfaction.

U.S. Pat. No. 5,251,664 discloses a check valve in a fuel delivery system between a pump and a fuel tank. The check valve is designed to reduce ticking noise generated during valve operation. It will be appreciated that the check valve disclosed in U.S. Pat. No. 5,251,664 is configured to connect to an upstream and downstream fuel conduit. Furthermore, the check valve disclosed in U.S. Pat. No. 5,251,664 is a standalone component in the fuel delivery system. As a result, the bulkiness of the fuel delivery system is increased. Moreover, the valve disclosed in U.S. Pat. No. 5,251,664 is L-shaped. This type of shape increases losses in the fuel delivery system.

The inventors herein have recognized the above issues and developed a fuel delivery system. The fuel delivery system includes an elastic fuel line positioned between a first fuel pump and a second fuel pump and a check valve positioned in the elastic fuel line, the check valve including an external housing having a peripheral surface with a greater diameter than an unstretched inner diameter of the elastic fuel line. Sizing of the check valve and corresponding fuel line in this way enables the check valve to be securely fitted into the fuel line. Specifically, the stretched fuel line exerts a radial force on the check valve to secure the valve in a desired location in the fuel line. In this way, the check valve may be easily integrated into existing fuel lines without introducing a standalone check valve unit, if desired. As a result, the compactness of the fuel delivery system can be increased. Moreover, the check valve attenuates pressure pulsations in the fuel line, thereby reducing NVH in the fuel delivery system. Thus, the technical results achieved via the aforementioned engine system include increasing the system's compactness and decreasing pulsations in the fuel delivery system, thereby increasing the system's longevity and decreasing NVH in the system.

The above advantages and other advantages, and features of the present description will be readily apparent from the following Detailed Description when taken alone or in connection with the accompanying drawings.

It should be understood that the summary above is provided to introduce in simplified form a selection of concepts that are further described in the detailed description. It is not meant to identify key or essential features of the claimed subject matter, the scope of which is defined uniquely by the claims that follow the detailed description. Furthermore, the claimed subject matter is not limited to implementations that solve any disadvantages noted above or in any part of this disclosure. Additionally, the above issues have been recognized by the inventors herein, and are not admitted to be known.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a schematic depiction of a vehicle having an engine and a fuel delivery system;

FIG. **2** shows an illustration of an example check valve positioned in an elastic fuel line;

FIG. **3** shows an illustration of another view of the check valve shown in FIG. **2**;

FIG. **4** shows another example check valve positioned in a fuel line;

FIG. **5** shows another example check valve; and

FIG. **6** shows a method for operation of a fuel delivery system.

DETAILED DESCRIPTION

A fuel delivery system is described herein. The fuel delivery system includes check valve positioned in an elastic fuel line. The check valve includes an external housing having a peripheral surface with a greater diameter than an unstretched inner diameter of the elastic fuel line. Sizing the check valve and fuel line in this manner enables the check valve to be securely integrated into the fuel line, without splitting the fuel line to add a standalone check valve assembly, if desired. As a result, the compactness of the fuel delivery system may be increased through the integration of the check valve into an existing fuel line, if desired. Additionally, it will be appreciated that the pressure pulsations may be generated by operation of a fuel pump upstream of the check valve. It will be further appreciated, that the check valve is configured to enable fuel to flow therethrough in a downstream direction when the pressure in the fuel line exceeds a threshold value. As a result pressure pulsations in the fuel line are reduced. Consequently, NVH in the fuel delivery system is reduced, thereby increasing fuel delivery system component longevity and customer satisfaction.

FIG. **1** shows a schematic depiction of a vehicle **10** including an engine **12**. The engine **12** is configured to implement combustion operation. For example, a four stroke combustion cycle may be implemented including an intake stroke, a compression stroke, a power stroke, and an exhaust stroke. However, other types of combustion cycles may be utilized in other examples. In this way, motive power may be generated in the vehicle **10**. It will be appreciated that the engine may be coupled to a transmission for transferring rotation power generated in the engine to wheels in the vehicle.

The engine **12** includes a cylinder **14**. However, engines having a different number of cylinders and configurations have been contemplated. For instance, the cylinder may be arranged in an inline configuration where the cylinders are positioned in a straight line, a horizontally opposed configuration, a V-configuration, etc. Thus, the cylinders may be arranged in banks, in one example. The cylinder **14** is mechanically coupled to a crankshaft (not shown).

The vehicle **10** includes an intake system **16** configured to provide air to the cylinder **14**. The fluidic communication between the intake system **16** and the cylinder **14** is denoted via arrow **18**. The intake system **16** may include a variety of components such as intake conduits, filters, a throttle, an intake manifold, etc.

The vehicle **10** further includes an exhaust system **20** configured to receive exhaust gas from the cylinder **14**. The fluidic communication between the cylinder **14** and the exhaust system **20** is denoted via arrow **22**. The exhaust system **20** may include exhaust conduits, an exhaust manifold, emission control devices (e.g., particulate filters, catalysts), etc.

The vehicle **10** further includes a fuel delivery system **50** configured to provide fuel to the cylinder **14**. The fuel delivery system **50** includes a fuel tank **52** configured to store a suitable combustible fuel such as gasoline, diesel, alcohol, etc. The fuel tank **52** includes a flange **53**, in the depicted example. The flange **53** is secured to the tank and provides a mounting feature for the fuel delivery module.

A lower pressure fuel pump **54** is also included in the fuel delivery system **50**. The lower pressure fuel pump **54** is enclosed in the fuel tank **52**, in the depicted example. However in other examples, the lower pressure fuel pump **54** may be positioned at least partially outside of the lower pressure fuel pump **54**. The lower pressure fuel pump **54** is configured to flow fuel to downstream components.

A fuel filter **56** included in the fuel delivery system **50** is positioned downstream of the lower pressure fuel pump **54** and therefore is in fluidic communication with the lower pressure fuel pump. The fuel filter **56** is configured to remove unwanted particulates from the fuel flowing therethrough. A restriction device **58** is also in fluidic communication with the lower pressure fuel pump **54**. The restriction device **58** is configured to move inaccessible fuel to the fuel delivery module.

A valve **60** is positioned downstream of the fuel filter **56** and therefore is in fluidic communication with the fuel filter **56** and the lower pressure fuel pump **54**. The valve **60** is a two-way valve, in the depicted example. The valve **60** has a first configuration permitting fuel to flow to downstream components. The valve **60** has a second configuration inhibiting fuel from flowing to downstream components and permitting fuel to flow back into the fuel tank **52**. The valve **60** may be electronically controlled via the controller **100**, in one example an electrical solenoid valve. However, in other examples the valve **60** may be passively controlled.

A check valve **62** is also included in the fuel delivery system **50**. The check valve **62** is configured to permit fuel to flow therethrough in a downstream direction when the pressure of the fuel in the fuel line upstream of the valve exceeds a threshold value. The check valve **62** is integrated into the fuel line **64**, in the depicted example. The fuel line **64** extends from the valve **60** to a higher pressure fuel pump **66**. Thus, the fuel line **64** provides fluidic communication between the valve **60** and the higher pressure fuel pump **66**. The check valve **62** is discussed in greater detail herein with regard to FIGS. **2**-**4**. The higher pressure fuel pump **66** is in fluidic communication with the check valve **62**. Therefore, the check valve **62** is positioned between the higher pressure fuel pump **66** and the lower pressure fuel pump **54**. The higher pressure fuel pump **66** is in fluidic communication with a fuel rail **68** and a fuel injector **70** providing metered amounts of fuel to the cylinder **14**. The fuel injector **70** is directly coupled to the cylinder **14** to provide what is known in the art as direct injection to the cylinder. Therefore, the fuel injector **70** may be referred to as a direct fuel injector. Additionally or alternatively, the port fuel injection may also be provided in the engine **12**.

A fuel line **72**, denoted via an arrow, provides fluidic communication between the valve **60** and the fuel filter **56**. Additionally, a return fuel line **74** is in fluidic communication with the valve **60** and includes an outlet opening into the fuel tank **52**. A fuel line **76** also provides fluidic communication between the lower pressure pump **54** and the fuel filter **56**. It will be appreciated that the aforementioned fuel lines are included in the fuel delivery system **50**. The fuel delivery system **50** may also include an external filter to increase filtration of fuels. **80**

A controller **100** may be included in the vehicle **10**. The controller **100** may be configured to receive signals from sensors in the vehicle as well as send command signals to components. Various components in the vehicle **10** may be controlled at least partially by a control system including the controller **100** and by input from a vehicle operator **132** via an input device **130**. In this example, input device **130** includes an accelerator pedal and a pedal position sensor **134** for generating a proportional pedal position signal PP. The controller **100** is shown in FIG. **1** as a microcomputer, including processor **102** (e.g., microprocessor unit), input/output ports **104**, an electronic storage medium for executable programs and calibration values shown as read only memory **106** (e.g., read only memory chip) in this particular example, random access memory **108**, keep alive memory **110**, and a data bus. Storage medium read-only memory **106** can be programmed with computer readable data representing instructions executable by processor **102** for performing the methods described below as well as other variants that are anticipated but not specifically listed. As shown, the lower pressure fuel pump **54** and the higher pressure fuel pump **66** receive control signals from the controller **100**. Therefore, the controller **100** may adjust the output of the fuel pumps (**54** and **66**). The fuel injector **70** also receives a control signal from the controller **100**. Therefore, the fuel injector **70** may also be configured to adjust the amount and timing of the fuel delivered to the cylinder **14** from the fuel injector **70**. The valve **60** also receives a control signal from the controller **100**.

FIG. **2** shows an example elastic fuel line **200**. The fuel line **200** may be similar to the fuel line **64** shown in FIG. **1**. Therefore, the elastic fuel line **200** may be in fluidic communication with a higher pressure fuel pump, such as the higher pressure fuel pump **66** shown in FIG. **1**, and a lower pressure fuel pump, such as the lower pressure fuel pump **54** shown in FIG. **1**. Specifically in one example, the elastic fuel line **200** may extend between a lower pressure fuel pump and a higher pressure fuel pump. As shown, the fuel line **200** including a housing **202**. Fuel flows through the elastic fuel line **200** in the direction indicated via arrow **204**. The elastic fuel line **200** includes a plurality of layers **206**. Thus, the elastic fuel line is a multi-layer fuel line, in the depicted example. However, in other examples, the elastic fuel line may include only a single layer. Additionally, the elastic fuel line **200** has an unstretched inner diameter **207**. It will be appreciated that the unstretched inner diameter includes a state of the fuel line where a substantially equal pressure is exerted on the inside and outside of the fuel line.

A check valve **210** is positioned in the fuel line **200**. The check valve **210** may be similar to the check valve **62**, shown in FIG. **1**. The fuel line **200** at least partially encloses the check valve **210**. The check valve **210** including an upstream end **212** (e.g., leading end) and a downstream end **214** (e.g., trailing end). The upstream end **212** includes a curved leading surface **215**. Additionally, the outer diameter of the upstream end **212** is greater than the outer diameter of the downstream end **214**. The curvature of this surface enables the valve to be inserted into the fuel line **200** without causing damage to the fuel line housing. As shown, the downstream end **214** is spaced away from the housing **202** of the elastic fuel line **200**. In other words, the downstream end **214** is not coupled or secured to the housing **202**. The check valve **210** is configured to permit fuel to flow therethrough in a downstream direction when the pressure in the elastic fuel line **200** upstream of the valve surpasses a threshold value. In one example, the threshold value is a few kpa higher than the downstream pressure. It will be appreciated that the check valve **210** attenuates pressure pulses traveling through the fuel line **200**, thereby reducing NVH in the fuel delivery system. As a result, the likelihood of component degradation is decreased and component longevity is increased. Additionally, customer satisfaction is also increased when the NVH is reduced. The check valve **210** further includes an external housing **216** having a peripheral surface **218**. The peripheral surface **218** is the outermost valve surface and is in face sharing contact with the housing **202** of the elastic fuel line **200**, in the depicted example. In this way, fuel may be substantially inhibited from flowing between the peripheral surface and the housing. Furthermore, it will be appreciated that the external housing **216** includes additional peripheral surfaces which have smaller diameters/radii than the outermost peripheral surface. The external housing **216** encloses valve componentry such as a spring, valve channels, etc. The diameter **219** of the peripheral surface **218** is illustrated. Further in the depicted example, a cross-section of the peripheral surface perpendicular to a central axis **250** of the check valve is circular. However, other check valve geometries have been contemplated.

In one example, the diameter **219** of the peripheral surface is greater than 105% of the unstretched inner diameter **207** of the elastic fuel line. Further in one example, the diameter **219** of the peripheral surface is between 101% and 120% of the unstretched inner diameter **207** of the elastic fuel line. Still further in one example, the diameter **219** of the peripheral surface is less than 5% a maximum threshold stretch of the elastic fuel line **200**. In this way, the check valve **210** may be secured in a desired location via an elastic force exerted on the valve via the elastic fuel line without stretching the elastic fuel line beyond a desired value, which may damage the line. As a result, the check valve **210** is internally integrated into the fuel line, thereby increasing the compactness of the fuel delivery system. Additionally, a ratio of an outer diameter of the upstream end **212** and the diameter of the peripheral surface **218** is 115 to 125%.

Furthermore, the elasticity of the fuel line **200** may be up to 130% of original size. Additionally, the elasticity of the fuel line **200** is greater than the elasticity of the check valve **210**. Furthermore, the elasticity of the fuel line **200** may be greater than the elasticity of upstream and/or downstream fuel lines in the fuel delivery system, in one example.

Additionally, a tapered surface **220** of the external housing **210** extends from the upstream end **212** to the outermost peripheral surface **218**. A divergent angle **222** of the tapered surface **220** extending from the upstream end **212** is between 20° and 40°. Additionally, in one example, the downstream end **214** of the check valve **210** is positioned greater than 15 mm from an end of the elastic fuel line **200**.

A quick connect **221** is also shown in FIG. **2**. The quick connect **221** is coupled to the elastic fuel line **200**. Additionally, the quick connect **221** may be coupled to downstream components such as a higher pressure fuel pump or a fuel line. It will be appreciated that the quick connect may include a barbed feature for sealing on fuel line. In one example, the quick connect **221** may be spaced at least 5 millimeters (mm) away from the downstream end **214** of the check valve **210**. The cutting plane **260** defining the cross-section shown in FIG. **3** is also illustrated in FIG. **2**.

FIG. **3** shows a cross-sectional view of the check valve **210** shown in FIG. **2**. Specifically, FIG. **3** shows the downstream end **214** of the check valve **210**. The check valve **210** includes weep channels **300** configured to allow for bleed off of fuel during non-operating conditions.

FIG. **4** shows an example check valve **400** positioned in a device **402**. The device **402** may be a quick connect device, in one example. In such an example, the quick connect device may be positioned between a higher pressure fuel pump and a lower pressure fuel pump shown in FIG. **1**. Additionally, the quick connect device may comprise plastic and/or steel. In another example, the device **402** may be a higher pressure pump fitting.

As illustrated, the check valve **400** includes a plurality of teeth **404** circumferentially extending around the valve housing **406**, is part of the quick connect body or can be part of a high pressure pump inlet fitting. The teeth **404** are formed by raised sections and depressed sections. Thus, the teeth may also be thought of as recessed channels. As shown, the teeth have an equivalent external circumference. However, in other examples the circumference of the teeth may vary along their lengths and/or vary between the teeth. The teeth **404** are spaced about one millimeter apart and have a height of about half a millimeter, these teeth **404** can be flat or have a special feature to allow for proper retention of the check valve.

FIG. **5** shows another example check valve **500**. Specifically, a cross-section of the check valve **500** is depicted. The check valve **500** includes an external housing **502**. Additionally, the check valve **500** includes teeth **504**. The teeth **504** are included in the housing **502**. Furthermore, the teeth **504** include peripheral surfaces **506**. The peripheral surfaces of one or more of the teeth may be greater than an unstretched inner diameter of an elastic fuel line in which the check valve **500** is positioned. Thus, it will be appreciated that the check valve **500** may be positioned in an elastic fuel line, such as the elastic fuel line **200** shown in FIG. **2**.

Continuing with FIG. **5**, weep channels **508** in the check valve **500** are depicted. Additional weep channel may also be included in the check valve **500**. Specifically, the additional weep channels may be included in the peripheral surface of the valve. For example, the weep channels may extend through the teeth. The weep channels **508** in the check valve **500** are configured to allow for bleed off of fuel during non-operating conditions. Specifically, the weep channels **508** may enable fuel to flow from opening **510** through the valve past an obstruction element **512** (e.g., ball) included in the valve **500**. It will be appreciated that the size of the weep channels may be selected based on desired bleed off characteristics of the valve.

The obstruction element **512** is attached to a spring **514**. The obstruction element **512** and spring **514** may work in conjunction to permit and inhibit flow through the check valve **500** based on the pressure the fuel line or other component upstream of the valve. The obstruction element **512** seats and seals on an inner surface **516** of the check valve **500** in a closed configuration. In an open configuration the obstruction element **512** is spaced away from the inner surfaced **516** and enables fuel to flow through the valve in a downstream direction. Additionally, the spring **514** is coupled to a stopper **518**. The stopper **518** may confine movement of the spring **514**.

FIG. **6** shows a method **600** for operation of a fuel delivery system. The method **600** may be implemented via the fuel delivery system **50** discussed above with regard to FIG. **1** or may be implemented via another suitable fuel delivery system.

The method includes at **602** attenuating pressure pulsations travelling from a higher pressure fuel pump to a lower pressure fuel pump via a check valve positioned in an elastic fuel line between the higher pressure fuel pump and the lower pressure fuel pump, the check valve including an external housing having a peripheral surface with a greater diameter than an unstretched inner diameter of the elastic multi-layer fuel line. In this way, the check valve may be secured in the fuel line via an elastic return force exerted on the valve via the fuel line. As a result, the check valve may be integrated into an existing fuel line, decreasing the cost of the fuel delivery system and increasing system's compactness, if desired. In one example, the check valve configured to enable fuel flow there through when the upstream fuel pressure in the elastic fuel line exceeds the downstream fuel pressure. As a result, the check valve reduces NVH in the fuel delivery system, thereby increasing components longevity and customer satisfaction. Next at **604** the method includes flowing fuel from the check valve to the high pressure fuel pump.

Note that the example control and estimation routines included herein can be used with various engine and/or vehicle system configurations. The specific routines described herein may represent one or more of any number of processing strategies such as event-driven, interrupt-driven, multi-tasking, multi-threading, and the like. As such, various actions, operations, and/or functions illustrated may be performed in the sequence illustrated, in parallel, or in some cases omitted. Likewise, the order of processing is not necessarily required to achieve the features and advantages of the example embodiments described herein, but is provided for ease of illustration and description. One or more of the illustrated actions, operations and/or functions may be repeatedly performed depending on the particular strategy being used. Further, the described actions, operations and/or functions may graphically represent code to be programmed into non-transitory memory of the computer readable storage medium in the engine control system.

It will be appreciated that the configurations and routines disclosed herein are exemplary in nature, and that these specific embodiments are not to be considered in a limiting sense, because numerous variations are possible. For example, the above technology can be applied to V-6, I-4, I-6, V-12, opposed 4, and other engine types. The subject matter of the present disclosure includes all novel and non-obvious combinations and sub-combinations of the various systems and configurations, and other features, functions, and/or properties disclosed herein.

The following claims particularly point out certain combinations and sub-combinations regarded as novel and non-obvious. These claims may refer to "an" element or "a first" element or the equivalent thereof. Such claims should be understood to include incorporation of one or more such elements, neither requiring nor excluding two or more such elements. Other combinations and sub-combinations of the disclosed features, functions, elements, and/or properties may be claimed through amendment of the present claims or through presentation of new claims in this or a related application. Such claims, whether broader, narrower, equal, or different in scope to the original claims, also are regarded as included within the subject matter of the present disclosure.

The invention claimed is:

1. A fuel delivery system comprising:

an elastic fuel line for gasoline or diesel fuel positioned between a first fuel pump and a second fuel pump; and

a check valve internally integrated into the elastic fuel line, the check valve including an external housing having a peripheral surface with a greater diameter than an unstretched inner diameter of the elastic fuel line, the external housing having an upstream end and a downstream end, the downstream end spaced away from the elastic fuel line, wherein an elasticity of the elastic fuel line is greater than an elasticity of the check valve, wherein a leading edge of the upstream end has a curved tapered leading surface, where a divergent angle of the curved tapered leading surface extending from the upstream end of the check valve is between 20° and 40° from a central axis, and where the curved tapered leading surface is spaced away from the elastic fuel line and tapers and curves away from an inner surface of the elastic fuel line to a greater degree than the fuel line curves or tapers due to its elastic expansion from the check valve inserted therein, where the elastic fuel line is coupled to a quick connect downstream of the check valve, the quick connect spaced at least 5 millimeters (mm) away from the downstream end of the check valve, the quick connect coupled to the second fuel pump.

2. The fuel delivery system of claim **1**, where the fuel line is a multi-layer fuel line positioned in a vehicle, and wherein the curved tapered leading surface is curved from the most upstream end to an outermost peripheral surface, wherein the second fuel pump is a higher pressure fuel pump than the first fuel pump.

3. The fuel delivery system of claim **2**, where the fuel line is a nylon fuel line.

4. The fuel delivery system of claim **1**, where the check valve includes a plurality of teeth circumferentially extending around an outer surface of the check valve.

5. The fuel delivery system of claim **4**, where the check valve includes weep channels directly connecting upstream and downstream for bleeding a high pressure side back into a low pressure side of the system during non-running conditions.

6. The fuel delivery system of claim **5**, where the diameter of the peripheral surface of the external housing is greater than 105% of the unstretched inner diameter of the fuel line.

7. The fuel delivery system of claim **1**, where the diameter of the peripheral surface of the external housing is between 101% and 140% of the unstretched inner diameter of the fuel line.

8. The fuel delivery system of claim **1**, where the downstream end of the check valve is positioned between 50 mm and 100 mm from an end of the elastic fuel line.

9. The fuel delivery system of claim **1**, where a cross-section of the peripheral surface perpendicular to the central axis of the check valve is circular.

10. A fuel delivery system of a vehicle comprising:

an elastic multi-layer fuel line for gasoline or diesel fuel positioned between a lower pressure fuel pump and a higher pressure fuel pump;

a check valve internally integrated into the elastic multi-layer fuel line, the check valve including an external housing having a peripheral surface with a greater diameter than an unstretched inner diameter of the elastic multi-layer fuel line and a curved and tapered leading surface, the peripheral surface being an outermost valve surface and in face-sharing contact with the elastic multi-layer fuel line, wherein the curved and tapered leading surface is formed at a divergent angle extending from an upstream end of the check valve between 20° and 40°, and where the curved and tapered leading surface is spaced away from the elastic fuel line and tapers and curves away from an inner surface of the elastic fuel line to a greater degree than the fuel line curves due to its elastic expansion from the check valve inserted therein, where the elastic fuel line is coupled to a quick connect downstream of the check valve, the external housing further comprising a downstream peripheral surface not in face-sharing contact with the elastic multi-layer fuel line, wherein an elasticity of the elastic multi-layer fuel line is greater than an elasticity of the check valve; and

a direct fuel injector in fluidic communication with the higher pressure fuel pump and directly coupled to a cylinder.

11. The fuel delivery system of claim **10**, where the diameter of the peripheral surface of the external housing is between 101% and 140% of the unstretched inner diameter of the fuel line.

12. The fuel delivery system of claim **11**, where the check valve includes weep channels directly connecting upstream and downstream for bleeding a high pressure side back into a low pressure side of the system during non-running conditions.

13. The fuel delivery system of claim **12**, where a ratio of an outer diameter of the upstream end of the check valve and the diameter of the peripheral surface is 1.2 to 1.4.

14. The fuel delivery system of claim **13**, where the diameter of the peripheral surface of the external housing is less than 5% of maximum threshold stretch of the elastic multi-layer fuel line.

15. The fuel delivery system of claim **14**, where the elasticity of the elastic multi-layer fuel line is greater than the elasticity of the check valve.

16. A method for operation of a fuel delivery system of a vehicle, comprising:

attenuating pressure pulsations travelling from a higher pressure fuel pump to a lower pressure fuel pump via a check valve internally integrated into an elastic multi-layer gasoline fuel line between the higher pressure fuel pump and the lower pressure fuel pump, the check valve including an external housing having a first peripheral surface with a greater diameter than an unstretched inner diameter of the elastic multi-layer gasoline fuel line and a second peripheral surface not coupled to the elastic multi-layer gasoline fuel line and including a leading edge of an upstream end having a curved tapered leading surface, where a divergent angle of the curved tapered leading surface extending from the upstream end of the check valve is between 20° and 40°, and where the curved tapered leading surface is spaced away from the elastic fuel line and tapers away from an inner surface of the elastic fuel line even where the fuel line narrows due to its elastic expansion from the check valve inserted therein, where the elastic fuel line is coupled to a quick connect downstream of the check valve, wherein an elasticity of the elastic multi-layer gasoline fuel line is greater than an elasticity of the check valve.

17. The method of claim **16**, where the check valve is configured to enable fuel flow therethrough when a fuel pressure in the elastic multi-layer fuel line exceeds about 10 kpa.

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